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An Anatomical Study of Fifty-seven Normal Skulls of White and Sixteen Normal Skulls of Colored Individuals. . . . . .

WITH THREE PLATES.

FROM THE PATHOLOGICAL INSTITUTE
OF THE NEW YORK STATE HOSPITALS,
AND THE DEPARTMENT OF ANATOMY,
COLUMBIA UNIVERSITY, NEW YORK.

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By ALES HRDLICKA, M. D.

Reprint from the Archives of Neurology and Psychopathology, V. I, No. 4, 1898.

State Hospitals Press, Utica, N. Y.

1899.

DIMENSIONS OF THE NORMAL PITUITARY FOSSA OR SELLA TURCICA IN THE WHITE AND THE NEGRO RACES.—AN ANATOMICAL STUDY OF FIFTY-SEVEN NORMAL SKULLS OF WHITE AND SIXTEEN NORMAL SKULLS OF COLORED INDIVIDUALS.

WITH THREE PLATES.

Since it has been repeatedly demonstrated that marked enlargements of the pituitary body are of a pathognomonic nature, it becomes desirable to learn the normal dimensions of the hypophysis, and also its normal range of variations in size.

The pituitary gland itself is not well adapted for accurate measurements.* The organ is small, very yielding, and does not present any positive landmarks for measuring. Furthermore, the gland is frequently injured in extraction. Under these circumstances we find an equally good if not much better subject for hypophyseal measurements in the enveloping bony fossa.

We have thought that measurements of the fossa might be of value in identifying and differentiating the skeletons of acromegalia and gigantism, osteo-arthropathie hypertrophiante, etc., and also be of some anthropologic value in the differentiation of races. We must, however,

* Zander records the variations in the diameters of the normal hypophysis as follows: Sagittal diameter, 6.0–10.5 mm.; frontal, 10.0–14.5 mm.; vertical, 5.0–9.75 mm. According to Schonemann, Boyce and Beadles the average weight is 0.6 gr.

remember that the measurements of the fossa can never be an infallible index of the condition of the hypophysis. This may be comparatively little changed in size and still be the seat of hyperplasia which Brooks, in the preceding paper, shows to be the specific and definite causal process in acromegalia. It should not be expected that the early phases of hyperplasia can be detected by measurements either of the pituitary body or fossa. Microscopical examination of the hypophysis with especial reference to cytologic structural details affords the only means of determining these early cellular changes accompanied by very slight enlargements of the hypophysis. These minor degrees of hyperplastic enlargement, although sufficient to initiate the train of acromegalic phenomena, might fall within the normal range of variations of the size of the hypophysis. On the other hand, enlargement of the pituitary fossa in the skeleton does not in every case indicate acromegalia, for Brooks shows that neoplasms of the hypophysis, although they may produce an enlargement of the fossa, have no causal relation to acromegalia. Thus we may expect to find enlargement of the pituitary fossa in non-acromegalic skeletons; and the earlier changes in acromegalic skeletons with but little if any enlargement of the fossa beyond the maximum of the normal range of variations. The latter condition, however, would be of rare and exceptional occurrence. In the great majority of cases the acromegalic skeleton must show various degrees of unmistakable enlargement of the pituitary cavity due to the gradual absorption of bone about the hyperplastic or adenomatous gland. Since enlargements of the hypophysis, not associated with acromegalia, are of very rare occurrence, an enlarged pituitary fossa, especially when associated with noticeable changes

in other parts of the skeleton, would convey at least a strong suspicion of acromegalia.

The pituitary fossa, or sella turcica, is not really a perfect mould of the hypophysis, but the excess is small and also constant in a series of measurements. In addition to the hypophysis the cavity generally contains some alveolar tissue. This is especially true of the anterior part of the sella and of its opening. The connective tissue, however, is never present in such amount as to materially influence the dimensions of the fossa which correspond very closely to the volume of the pituitary body. When the hypophysis enlarges, the sella enlarges correspondingly, both in size and direction. An independent enlargement of the sella or an independent increase of the connective tissue about the gland, has never been reported. Thus if we know both the average dimensions of the pituitary fossa and their possible variations in a normal state, any excess in the dimensions of the structure can be taken as a positive indication of an enlargement of the hypophysis through neoplasm or hyperplasia. Knowing the normal measurements and their variations, we would also be enabled to judge as to the degree of enlargement of the organ. Both these possibilities, especially when taken in conjunction with abnormal features in other parts of the skeleton, may occasionally prove of great value in determining a differential diagnosis.

Having access, through the courtesy of Prof. Huntington, to the Anatomical Department of the School of Medicine of Columbia University, where are large numbers of normal skulls, I undertook the task of ascertaining the average size and the limits of variations of the normal sella turcica.

The study was made separately on skulls of white males

and females; I measured also a number of skulls of male and female negroes, and the data will be included for comparison. Only normal and adult specimens have been included; I have not been able to obtain a sufficient number of skulls of children and adolescents, and am unable to give satisfactory data of the variations of the pituitary fossa during the growth period.

The first point in this investigation was to establish fixed landmarks, from which all subsequent measurements on different skulls could be taken. This proved to be quite difficult as the contours of the fossa are not well defined; the walls of both sides as well as the top being incomplete. The shape of the fossa differs from almost spheroidal, to obliquely or horizontally ellipsoidal; its walls and the immediate neighboring parts are subject to much variation in different skulls.

The more or less rounded shape of the sella renders it fit for three measurements, namely, maximum length, width, and depth. To clearly indicate the landmarks for these three measurements,—landmarks which I decided upon only after numerous trials,—it will be necessary to review with some detail the anatomy of the fossa and adjacent bony structures.

Proceeding from the posterior angles of the cribriform plate of the ethmoid, backward along the flat surface of the body of the sphenoid, the first distinct structure met with is a low, but in a large majority of cases, well defined transverse ridge. (Fig. 1, *a*).* This bony elevation marks the anterior boundary of a slightly depressed space, which contains anteriorly a slight furrow, the optic groove, and behind this an elevation, the olivary eminence. The extremities of the ridge surmount the optic foramina and

* The indices in this description refer to Figs. 1 and 2 of Plate I.

blend with the bases of the anterior clinoid processes. This ridge, which may advantageously be termed the *anterior olivary ridge*, is from 2.0 cm. to 3.0 cm. long, and usually about 1.2 cm. posterior to the posterior angles of the cribriform plate.

The space which contains the optic groove and the olivary eminence is, as will be seen later, of a certain importance and deserves a close description.

The optic groove is seldom perfect and frequently is very shallow or indistinct. The surface of the olivary eminence is more or less convex, both laterally and antero-posteriorly. The antero-posterior convexity varies considerably, in some cases the surface is almost flat, while in others the posterior part of the surface slopes down very abruptly. Laterally the olivary eminence is bounded by the carotid *semi-foramina*. Posteriorly, the boundary of the eminence is formed by another distinct and almost constant bony elevation, which terminates on each side in a short, sharp point, termed the second or middle clinoid process. This second, or *posterior olivary ridge*, forms the anterior border of the pituitary fossa, and its centre (Fig. 1, *b*), is our first landmark, namely, the anterior point from which we take the antero-posterior diameter, or the length, of the sella turcica.

The space between the anterior and posterior olivary ridges is bounded laterally by the mesial surfaces of the anterior clinoid processes. If well formed, these processes proceed from the extremities of the anterior olivary ridge, in front and outside of the optic foramina. Their mesial lines converge (in a few skulls they diverge) a little in their distal half. Their external lines, which are continuous with the posterior borders of the lesser wings of the sphenoid, converge gradually throughout

their whole length. These two lines, *i. e.*, the inner and outer borders of the anterior clinoid process, meet in a sharp or blunt point, marking the free extremity of the process. These extremities are usually about opposite the middle of the sella turcica; in some skulls they terminate somewhat more anteriorly. They can be utilized, as will be seen later, for landmarks of a certain measurement.

Progressing still backward from the posterior olivary ridge, we meet the sella turcica itself, which presents for examination an anterior and posterior wall, and a base; the sides and roof are deficient.

Holding the skull in its standard position, (*i. e.*, horizontal or alveolo-condylian line of Broca), we see that the anterior wall of the pituitary fossa is not vertical, but slopes somewhat downwards and backwards. From side to side it is flattened, or slightly concave, especially at the base. The borders of this anterior wall are very blunt and convex, sloping away gradually into the carotid depressions on their exterior.

The base of the pituitary fossa is generally somewhat narrower than the anterior wall, although the gradual outward slope may give the appearance of greater breadth. The direction of the base may be almost horizontal, but, most frequently, and especially in the female, it is inclined in varying degrees downward and backward. The sides slope to the considerably lower level of the carotid grooves.

The surface of the base shows an oblong, more or less shallow but distinct depression, which lodges the lower part of the hypophysis. The borders of this depression are usually well marked, and as directly beyond them the parietes begin to slope downward, they offer us the only possible landmarks from which to measure the width

of the pituitary fossa. For this measurement we choose the highest points on these borders, where they are most widely separated (Fig. 1, *e e*). Occasionally, unusual breadth and indefiniteness of these borders may make selection of the proper points somewhat difficult, but such instances are exceptional, and with some care the proper measure can generally be determined. The width thus obtained will be but little less than the maximum width of the hypophysis but sufficiently accurate for all practical purposes.

Posteriorly, the pituitary fossa is surmounted by a high, flat process of bone, the dorsum sellæ. This bony lamella rises from above the spheno-occipital suture, and in the adult skull is directly continuous with the basilar process of the occipital bone. It is inclined somewhat forward, and in some cases is narrower at the base than at the top. The top of the lamella is free, and the margins irregular and thickened. The superior border presents a more or less marked notch in the middle, and terminates on each side in a small conical body, the third or posterior clinoid process. Posteriorly, the dorsum sellæ is rough and flat, while the lower part is slightly concave. This concavity is continuous with that of the basilar process, together forming a distinct, broad groove. Anteriorly (ventrally) the dorsum is in most cases but slightly concave; however, in a certain percentage of cases it shows a pronounced rounded depression.

For our purpose of measuring the sella turcica, the most interesting part of the dorsum sellæ is the middle of the anterior edge of its upper border (Fig. 1, *c*). This point is the only suitable posterior landmark for the measurement of the antero-posterior diameter of the fossa, the anterior landmark being, as already stated, the middle of the posterior olivary ridge (Fig. 1, *b*).

The notch in the centre of the upper border of the dorsum sellæ, as well as the occasional marked depression on its ventral surface, are indications of an original deficiency in the lamella and we find such a deficiency in varying degrees in lower animals. Occasionally (in man), the notch is unusually deep, and in such a case our posterior landmark for the length measure of the fossa must be shifted a little on the anterior edge of the dorsum to one or the other side of the notch. Such a shifting of one landmark of the measure will not cause any appreciable change in the value of this measurement. The thickness of the upper border of the dorsum sellæ should never be included in this measurement; it is very uneven in different skulls.

The lateral and the antero-posterior diameters obtained, it remains for us to measure the depth of the fossa. The best method, I find, for taking this measure is as follows, lay a thin, narrow piece of steel or wood over the fossa from before backwards: its anterior end should rest on the top of the olivary eminence, and its posterior part should lie over the notch in the superior border of the dorsum sellæ (Fig. 2, *c*). From the under surface of this improvised roof, when in the proper position, we secure a perpendicular to the deepest depression in the base of the pituitary fossa; the length of this line is the measurement of the depth of the fossa (Fig. 2, *x* to *f*). This perpendicular measure is best obtained by a small, graduated steel rod; with a little more care it may be accurately determined by a delicate compass.

The most simple and practical way to make this measure is to use a piece of an old steel tape measure for the horizontal lamella or roof, and a tooth-pick for the vertical rod, pressing the latter, when in the proper position, a

little against the sharp edge of the former, and then measuring on the tooth-pick the height of the indentation.

The depth thus obtained is generally a little too great, but the excess is seldom more than 1 mm. and is unavoidable. This variation is not corrected in our calculations. Theoretically, the proper anterior landmark in measuring the depth of the sella would be the posterior olivary ridge. (Fig. 2, *b*). This ridge, however, though fully satisfactory for the length measurement, is in different skulls situated at such varying planes of height, that it can not be assumed to represent in every case the real height of the hypophysis and can not be well utilized for the depth measure. The point of the olivary eminence, though a little too high, is a much more stable landmark. Furthermore, the measurement from this point is very much easier to take than from the posterior olivary ridge.

The three principal measurements of the pituitary fossa obtained, we may consider two secondary ones. When we look at the region of the fossa from above, we notice that the anterior olivary ridge, the inner surface of the first or anterior clinoids, and the anterior line of the superior border of the dorsum sellæ, form an interrupted bony ring, situated somewhat above (superior to) the fossa itself. In some skulls this ring is completed through the union of the first and the third clinoid processes. This ring is capable of two measurements, the length and the width. The width of the ring is the distance between the points of the anterior clinoids. The antero-posterior diameter of the ring can be obtained from the centre of the anterior olivary ridge to the centre of the superior border of the dorsum sellæ. (Fig. 2, *a* to *c*). These measurements, however, are of little medical or anatomical importance.

Having discussed in detail the conformation and the manner of obtaining the measures of the pituitary fossa, I can now give the results of the measurements.

In the manner described above the sellæ were measured in four series of skulls of various white races and in two other series of American negroes. The number of specimens in the first two series I consider sufficient for the establishment of a correct average of measurements, and the scales of normal variations are undoubtedly almost complete. The number of the negro skulls is somewhat small; nevertheless they are sufficient to indicate in a gross way the essential similarities and differences of measurement in the pituitary fossæ of the white and black families. I should expect these differences to be more marked in pure African negroes, in whom all chances of admixture of white blood could be excluded.

I did not stop at the crude principal measurements of the fossa, but have endeavored to establish certain comparisons, in order to control the simple measurements.

It would seem reasonable to assume that the volume of the pituitary fossa would bear some relation to the capacity of the skull. The volume or capacity of the skull increases in certain proportion with the size and particularly with the height of the body, and the pituitary fossa, being a part of the cavity of the skull, might be expected to enlarge correspondingly.

Thus we would expect to find a perceptibly larger pituitary fossa in the male skulls as compared with female skulls and a smaller fossa in smaller people of either sex.

But it is quite difficult to obtain the correct cubical volume of the pituitary fossa, and in most of the cases I examined, a previous opening of the skull made a measure

of the capacity of the skull impossible. It was necessary, then, to look for the most satisfactory substitute for capacity.

Of head measurements no single one furnishes a reliable index of the size of the cranium. The most satisfactory substitute for skull capacity is expressed by the maximum circumference of the cranial vault, and we have utilized this measure in place of that of cranial capacity.

In the place of the capacity of the pituitary fossa, we can utilize any of its three principal diameters. I found it far more satisfactory, however, to secure an average of the length, width and depth of the fossa, and compare this average with the circumference of the skull. This average constitutes a module, which is a purely mathematical, but none the less practical, substitute for the real capacity measure of the fossa, and corresponds to the skull module of Schmidt,* *i. e.*,

$$\frac{Length + Width + Height\ of\ Skull,\ Max.}{3}$$

By comparing the module of the pituitary fossa with the maximum circumference of the same skull, we obtain a number which clearly expresses the size relation of the two measures, and this is sufficient for our purpose.

To obtain this number, we first state the module of the pituitary fossa, according to the formula of Schmidt:

$$\frac{Length + Width + Depth}{3}$$

Multiply this by 1000 and divide the result by the circumference of skull expressed in centimetres. The module of the fossa is thus expressed in thousandths of the circumference measurement of the skull.

* This formula has proven very valuable to the anthropologist.

We might choose the percentage instead of the per thousand, but the resulting number would be very small and inconvenient.

I think that the measurements of the pituitary fossæ of the four series of skulls mentioned should be given in detail. If so stated, the reader who may wish to give a closer attention to the subject will find himself supplied with ample data. These detail measures, however, can well be placed in an appendix, not to disturb the continuity of the paper. In this place I will state only the averages and the variations of the measures for each group.

THE LENGTH, OR ANTERO-POSTERIOR DIAMETER OF THE PITUITARY FOSSA. (See Plate II, Fig. 1).

	White Male.	White Female.	Negro Male.	Negro Female.
Averages:	1.11 cm.	1.00 cm.	1.09 cm.	1.06 cm.
Variations:	0.75–1.45 cm.	0.75–1.30 cm.	0.85–1.25 cm.	0.80–1.40 cm.

In the cases of the white male and white female, where the number of skulls examined is large, the variations can be expressed to advantage graphically by columns or curves. (See Plate II, Fig. 1):

The wide variation of the length measure is striking. The same thing will be observed more or less with the other measures of the pituitary fossa. The maximum of variation reaches with some of the measures fully 100 per cent. Nevertheless, the majority of measurements of each series, group themselves around the average and the extremes must be considered as exceptions.

The average length of the fossa does not differ greatly in the four series. There is a decided difference in the dimensions of the white male and white female, the latter averaging about 1 mm. shorter. There is a similar but much smaller difference between the sexes in the negro.

The scale of variations appears to be much smaller in the negro male than in the white male.*

No very appreciable or stable differences in the measurements could be found corresponding to brachy- or dolichocephaly. The average length of the fossa, however, is less in the very short than in the very long skulls. This condition is corroborated by the two maxima around the averages shown in the columns which represent the length variations. (Plate II, Fig. 1). The other two measures of the fossa, namely, width and depth, do not show appreciable and stable differences relative to the shape of the skull.

The Width, or Lateral Diameter of the Pituitary Fossa.
(See Plate II, Fig. 2).

	White Male.	White Female.	Negro Male.	Negro Female.
Averages:	1.15 cm.	1.08 cm.	1.05 cm.	1.21 cm.
Variations:	0.70–1.50 cm.	0.80–1.50 cm.	0.95–1.40 cm.	1.00–1.55 cm.

The differences in the four series are somewhat more pronounced in the width measurements than in the length. The average fossa in the white female is again appreciably smaller than that of the white male. Curiously, this difference in the black is reversed; the breadth of the female fossa averaging 1.6 mm. greater than the male. This difference cannot be satisfactorily explained. Comparisons of the fossæ of the black and the white male show a lesser width as well as length in the latter. The scales of variation are again decidedly smaller in the black.

Depth of the Pituitary Fossa.
(See Plate II, Fig. 3).

	White Male.	White Female.	Negro Male.	Negro Female.
Averages:	0.91 cm.	0.94 cm.	0.93 cm.	0.91 cm.
Variations:	0.60–1.20 cm.	0.60–1.30 cm.	0.65–1.10 cm.	0.80–1.00 cm.

*This result may be partially due to the comparatively smaller number of negro male skulls represented in the figures.

The depth averages of these four groups are very uniform. But while in the white it is the female, in the black it is the male whose average depth is somewhat greater. The scales of variation are again much smaller in the negro.

According to these three measures, we see that the three dimensions of the fossa do not differ very much in their values. According to these figures the width of the fossa is its greatest, and the depth its least measure.

The average of the fossæ of the white male, is longer, broader, and slightly shallower than that of the white female, and also longer, broader and shallower than that of the male negro. This would tend to approach the types of the fossa in the negro male and the white female.

Of the negro male and female the pituitary fossa of the male is the longer, narrower and deeper.

These differences among the principal measures of the fossa can also be expressed by indices, but these present no special advantages.

These three measures (length, width and depth) form the constituents of the module and this reflects their combined character. We find the module of the pituitary fossa for each of the four series of skulls to be as follows:

	White Male.	White Female.	Negro Male.	Negro Female.
Averages:	1.057	1.006	1.056	1.062
Variations:	.867–1.167	.867–1.250	.967–1.200	.900–1.217

The figures express clearly that the fossæ of the males of the two human families are of almost identical volume. The fossa of the white female is slightly smaller than that of the white male, while in the negro there is a very small increase in size in favor of the female.

The variations of the module are interesting to observe. Their range is very much smaller than that of the indi-

vidual measures, which is a proof that the measures of the fossa largely compensate each other. Because of this quality of the module, it is of greater value than the individual measurements.

There remain to be pointed out the relations of the size of the pituitary fossa to the circumference of the skull. We would meet with disappointment if we should expect to find a regular correspondence of those two values. Nevertheless there is a certain correspondence, for as we proceed to larger skulls, generally speaking, the fossa, also, will be found larger. This point cannot be better illustrated than by giving here the module circumference relations in detail. I will arrange these cases without relation to sex or color, neither of which seems to make any difference in this point, beginning at the lowest and advancing to the highest circumference.

Circumf. Max.	Module of Pituitary Fossa.	Relation of Module to Circumf.
48.0 cm.	1.000 cm.	20.8 cm.
50.2 cm.	0.967 cm.	18.6 cm.
50.8 cm.	1.083 cm.	21.3 cm.
51.0 cm.	0.917 cm.	18.0 cm.
51.2 cm.	0.917 cm.	17.8 cm.
51.3 cm.	0.950 cm.	18.5 cm.
51.5 cm.	0.900 cm.	17.4 cm.
51.6 cm.	1.033 cm.	20.0 cm.
51.7 cm.	1.050 cm.	20.3 cm.
52.0 cm.	0.983 cm.	18.9 cm.
52.0 cm.	0.967 cm.	18.6 cm.
52.3 cm.	1.167 cm.	22.3 cm.
52.7 cm.	1.067 cm.	20.2 cm.
53.0 cm.	1.133 cm.	21.4 cm.
53.0 cm.	1.117 cm.	21.1 cm.
53.2 cm.	1.117 cm.	21.0 cm.
54.2 cm.	1.050 cm.	19.4 cm.
54.5 cm.	1.083 cm.	19.9 cm
55.0 cm.	1.017 cm.	18.5 cm.
56.0 cm.	1.133 cm.	20.2 cm.

Divided into groups of five, these figures give the following averages:

Circumference.	Average Module.	Average Relation of Module to Circum.
48.0–51.2 cm. incl.	0.977 cm.	19.3 cm.
51.3–52.0 cm. incl.	0.983 cm.	19.0 cm.
52.0–53.0 cm. incl.	1.090 cm.	20.7 cm.
53.2–56.0 cm. incl.	1.080 cm.	19.8 cm.

According to the above figures the average module, or the size of the pituitary fossa as represented by the modules, increases with the greater size of the skull, but apparently the increase ceases after the average size of the skull is passed. The maximum of the ratio of the module to the circumference corresponds to the maximum of the size of the fossa.

It is not possible to establish from the foregoing data any law of correspondence of the proportion of the fossa to the circumference of the skull. This will be appreciated by the accompanying drawing. (Plate III, Fig. 1).

The paper might be finished here were it not for a peculiar difference of a little structure adjoining the pituitary fossa, in the white and in the negro. I refer to the space bounded by the anterior and posterior olivary ridges and including the optic groove and the olivary eminence.

This space is, in general, very much narrower antero-posteriorly in the negro than in the white, and that in both sexes. The defect concerns especially the olivary eminence.

Following are the antero-posterior measures of this space:

	White Male.	White Female.	Negro Male.	Negro Female.
Averages:	0.562 cm.	0.611 cm.	0.425 cm.	0.386 cm.
Variations:	0.20–0.∞5 cm	0.30–0.85 cm.	0.25–0.70 cm.	0.10–0.70 cm.

The greater antero-posterior narrowness of the space in the negro is very evident. It can be expressed to a further advantage by the following curves. (Plate III, Fig. 2).

The significance of marked difference in the antero-posterior extent of the space containing the optic tract and the olivary eminence, in the white and the negro, is obscure, but some light may be thrown on it by futher investigations at autopsies.

The medical value of these measurements lies in the fact, that they represent the dimensions which the pituitary fossa may acquire, in individual directions as well as a whole, in the normal state. Should in a given case, and particularly in a white person, any individual measure of the fossa, taken with care and according to the rules laid down in this paper, markedly exceed the variations of the same measure here recorded, such a measure may safely be considered abnormal. On the other hand, no pituitary fossa can safely be considered as abnormal in size so long as its individual measure, and its module, are not above the variations of the same measures here recorded.

In an appendix will be found a reference list of the detail measures of the pituitary fossa on the four series of skulls examined.

APPENDIX.

The detail measurements of the four series of skulls:

SKULLS OF WHITE MALE ADULTS.—TABLE I.

No.	Diameter ant. post.	Width.	Depth.	Diameter later. bet. pts. of ant. clinoids.	Diameter a-post to ant. border of oliv. emin.	Distance bet. the two oliv. ridges.	Module. $\frac{W+L+D}{3}$	Circumf. of skull.	Relation of module to circ. $\frac{M \times 1000}{C}$
1	1.25 cm.	1.25 cm.	0.85 cm.	1.45 cm.	1.65 cm.	0.40 cm.	1.117 cm.	53.2 cm.	21.0 cm.
2	1.25	1.15	0.95	2.35	1.60	0.35	1.117	?	?
3	1.00	0.75	0.95	2.10	1.60	0.60	0.900	?	?
4	1'10	1.30	1.00	2.60	1.70	0.60	1.133	?	?
5	1.00	1.30	1.10	?	?	?	1.133	56.0	20.2
6	0.75	1.45	0.75	2.70	1.45	0.70	0.983	52.0	18.9
7	0.85	1.10	1.10	2.70	1.45	0.60	1.017	55.0	18.5
8	1.40	1.10	0.95	2.50	1.80	0.70	1.150	?	?
9	1.30	1.30	0.80	2.80	1.90	0.60	1.133	53.0	ab't 21.4
10	1.15	1.50	0.80	2.90	1.75	0.60	1.150	?	?
11	1.20	1.10	1.00	2.45	1.70	0.50	1.100	?	?
12	1.05	1.30	0.85	?	1.90	0.85	1.067	?	?
13	1.20	1.40	0.60	2.50	1.95	0.75	1.06	52.7	20.2
14	1.05	1.50	0.95	?	1.60	0.55	1.167	?	?
15	0.90	0.95	0.90	?	1.45	0.55	0.917	?	?
16	0.90	1.20	1.00	2.40	1.60	0.70	1.033	?	?
17	1.45	0.85	0.90	?	2.00	0.55	1.067	?	?
18	1.00	1.25	1.00	1.80	1.60	0.60	1.083	?	?
19	1.30	0.90	0.95	2.40	2.00	0.70	1.050	54.2	19.4
20	1.25	1.40	0.70	2.70	1.80	0.55	1.117	?	?
21	1.00	1.20	1.00	?	1.70	0.70	1.067	?	?
22	1.15	1.00	0.90	?	?	?	1.020	?	?
23	0.95	1.00	0.80	2.30	1.30	0.35	0.917	?	?
24	1.20	0.70	0.70	?	?	?	0.867	?	?
25	1.10	1.15	1.20	1.80	1.50	0.40	1.150	?	?
26	1.40	1.00	0.95	?	?	?	1.117	?	?
27	1.10	1.10	0.70	?	?	?	0.937	?	?
28	1.20	1.10	0.90	2.00	1.60	0.40	1.067	?	?
29	1.00	1.00	0.80	1.80	1.20	0.20	0.933	?	?
30	1.25	1.00	1.15	2.30	1.80	0.55	1.133	?	?

APPENDIX.—(*Continued*).

SKULLS OF WHITE FEMALE ADULTS.—TABLE II.

No.	Diameter ant. post.	Width.	Depth.	Diameter later. bet. pts. of ant. clinoids.	Diameter a-post. to ant. border of oliv. emin.	Length of olivary eminence.	Module. $\frac{W+L+D}{3}$	Circumf. of skull.	Relation of module to circ. $\frac{M \times 100}{C}$
1	0.90 cm.	1.00 cm.	0.70 cm.	2.00 cm.	1.70 cm.	0.80 cm.	0.867 cm.	?	?
2	1.15	1.50	1.10	2.60	2.00	0.85	1.250	?	?
3	0.80	1.00	0.90	2.20	1.45	0.65	0.900	51.5	17.4
4	0.80	1.10	0.90	?	1.40	0.60	0.933	?	?
5	1.00	1.35	0.80	2.45	1.55	0.55	1.050	51.7	20.3
6	1.15	1.10	0.60	1.75	1.60	0.45	0.950	51.3	18.5
7	0.95	1.10	0.70	?	1.65	0.70	0.917	?	?
8	0.90	1.00	1.20	?	1.50	0.60	1.033	?	?
9	1.30	0.95	0.85	?	1.90	0.60	1.033	51.6	20.0
10	1.15	0.85	0.90	2.40	1.90	0.75	0.967	50.2	18.6
11	0.90	0.90	0.95	?	1.20	0.30	0.917	?	?
12	0.80	0.80	1.15	?	1.50	0.70	0.917	51.0	18.0
13	0.90	1.25	0.95	?	1.45	0.55	1.033	?	?
14	1.05	0.90	1.10	?	1.60	0.55	1.017	?	?
15	1.05	1.00	1.00	?	1.90	0.85	1.017	?	?
16	0.90	1.25	0.95	2.30	1.55	0.65	1.033	?	?
17	0.75	1.00	1.00	?	1.35	0.55	0.917	?	?
18	0.95	0.90	0.90	2.15	1.60	0.65	0.917	?	?
19	1.05	1.20	1.10	2.40	1.45	0.40	1.083	49.0	22.0
20	0.75	1.20	0.80	2.60	1.20	0.54	0.917	51.2	17.8
21	1.10	1.30	0.85	2.70	1.70	0.60	1.083	50.8	21.3
22	1.15	1.10	1.25	?	1.50	0.35	1.167	?	?
23	1.15	1.10	1.00	?	1.80	0.65	1.083	?	?
24	1.30	1.10	0.75	2.35	2.15	0.85	1.050	50.5	20.8
25	1.20	0.85	1.00	?	?	?	1.017	51.0	19.9
26	0.90	1.15	1.30	2.15	1.50	0.60	1.117	?	?
27	1.00	1.20	0.75	?	1.65	0.65	0.983	ab't 50.7	ab't 19.4

APPENDIX.—(*Continued*).

SKULLS OF NEGRO MALE ADULTS.—TABLE III.

No.	Diameter ant. post.	Width.	Depth.	Diameter later. bet. pts. of ant. clinoids.	Diameter a-post to ant. border of oliv. emin.	Length of olivary eminence.	Module. $\frac{W+L+D}{3}$	Circumf. of skull.	Relation of module to circ. $\frac{(M\times 100)}{C}$
1	1.20 cm.	1.20 cm.	0.95 cm.	2.00 cm.	1.55 cm.	0.35 cm.	1.117 cm.	?	?
2	1.00	1.00	0.95	2.40	1.70	0.70	0.983	?	?
3	1.25	1.20	0.90	2.10	1.50	0.25	1.117	53.0	21.1
4	1.00	0.95	0.95	?	1.65	0.65	0.967	52.0	18.6
5	?	1.15	1.10	2.25	1.15	?	?	?	?
6	1.15	1.05	0.70	?	1.40	0.25	0.967	?	?
7	1.20	1.40	1.00	2.45	1.60	0.40	1.200	51.5	23.3
8	0.85	1.20	1.00	?	1.25	0.40	1.017	?	?
9	1.10	1.30	0.85	3.10	1.50	0.40	1.083	54.5	19.9

SKULLS OF NEGRO FEMALE ADULTS.—TABLE IV.

No.	Diameter ant. post.	Width.	Depth.	Diameter later. bet. pts. of ant. clinoids.	Diameter a-post. to ant. border of oliv. emin.	Length of olivary eminence.	Module. $\frac{W+L+D}{3}$	Circumf. of skull.	Relation of module to circ. $\frac{M\times 100}{C}$
1	0.80 cm.	1.00 cm.	0.90 cm.	2.25 cm.	1.20 cm.	0.40 cm.	0.900 cm.	?	?
2	1.00	1.00	0.90	2.20	1.20	0.20	0.967	?	?
3	0.85	1.30	0.85	2.20	1.30	0.45	1.000	48.0	20.8
4	1.10	1.55	1.00	2.60	1.80	0.70	1.217	49.5	24.6
5	1.40	1.30	0.80	2.30	1.95	0.55	1.167	52.3	22.3
6	1.00	1.00	1.00	2.25	1.10	0.10	1.000	?	?
7	1.30	1.30	0.95	?	1.60	0.30	1.183	?	?

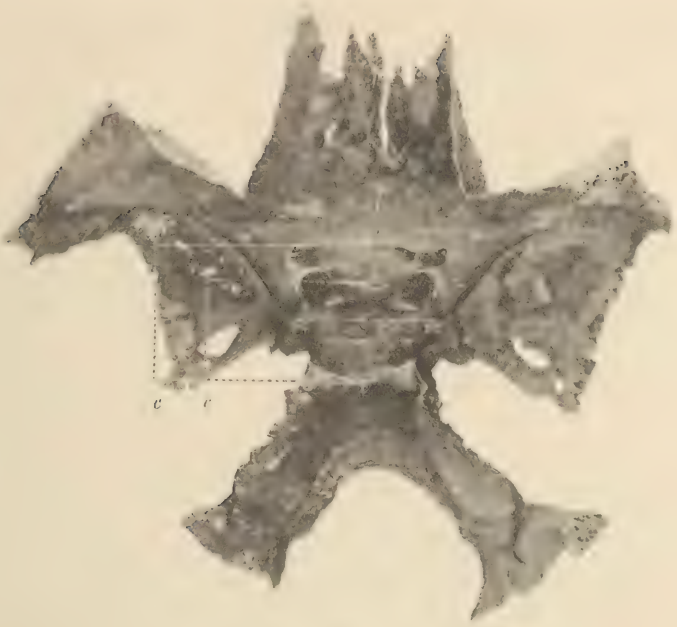

FIG. 1.

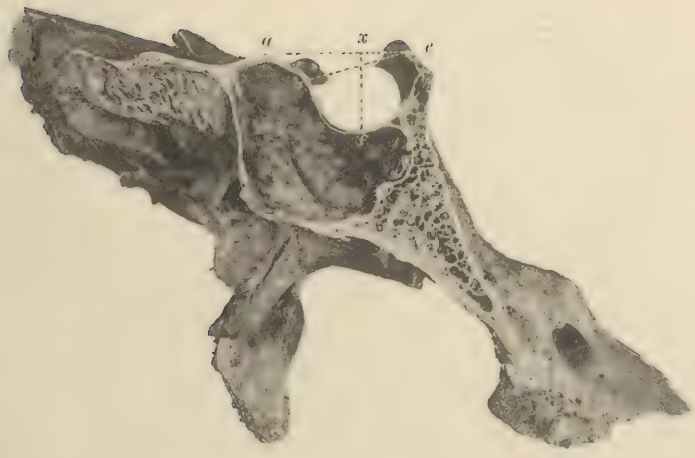

FIG. 2.

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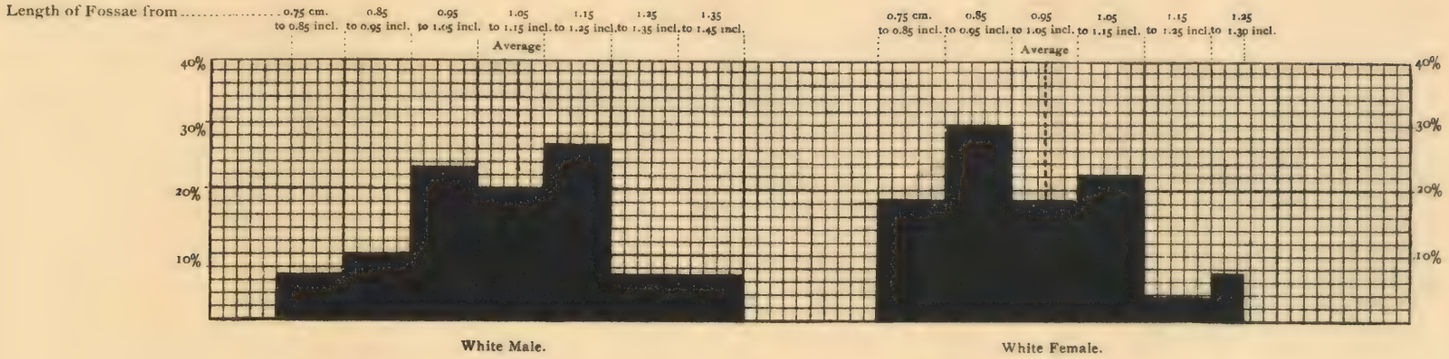

FIG. 1.—CURVES SHOWING THE PERCENTAGE OF FOSSAE WITHIN EACH *length* VARIATIONS OF 1 MM.

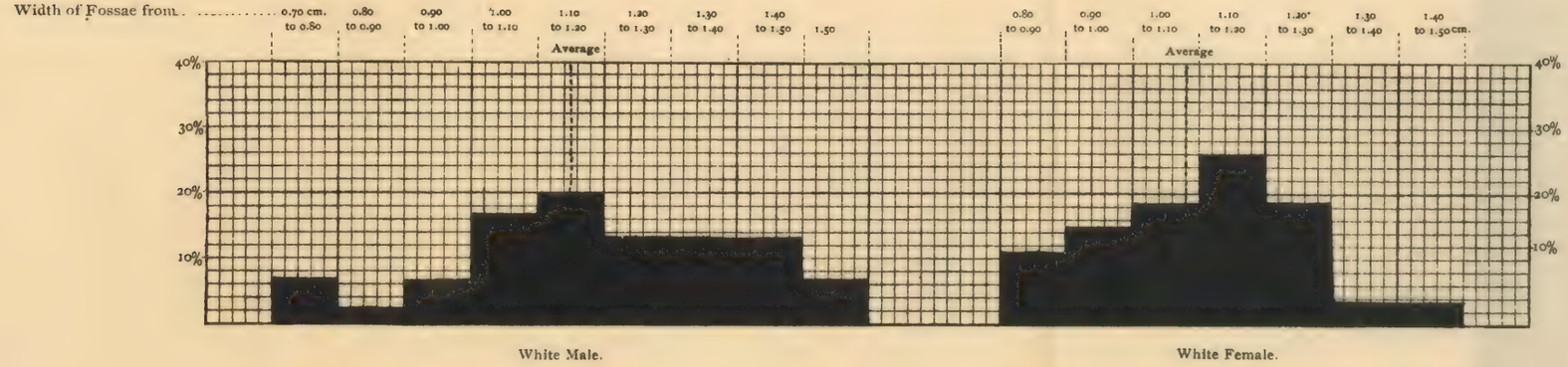

FIG. 2.—CURVES SHOWING THE PERCENTAGE OF FOSSAE WITHIN EACH *width* VARIATIONS OF 1 MM.

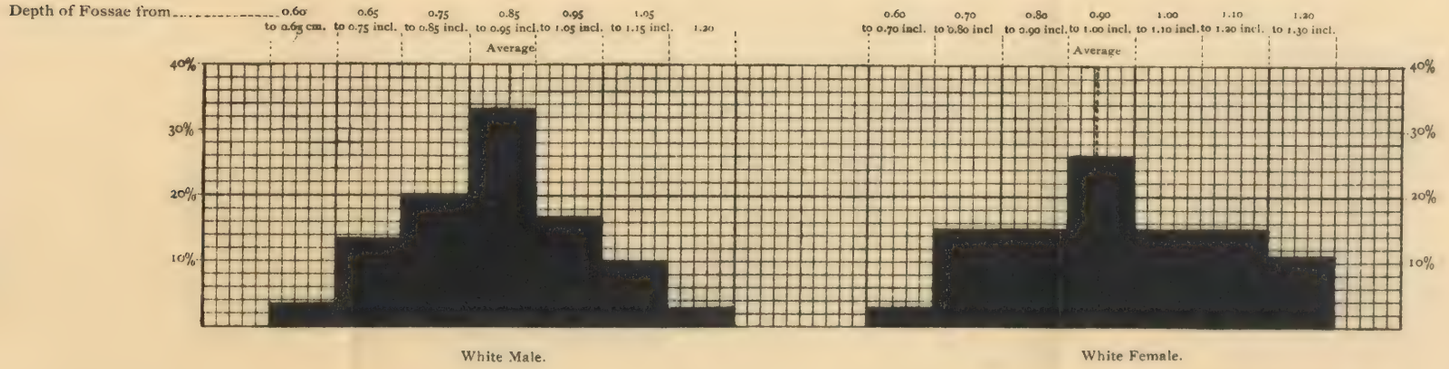

FIG. 3.—CURVES SHOWING THE PERCENTAGE OF FOSSAE WITHIN EACH *depth* VARIATIONS OF 1 MM.

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FIG. 1.—RELATIONS OF THE MODULE OF THE PITUITARY FOSSA TO THE CIRCUMFERENCE OF THE SKULL.

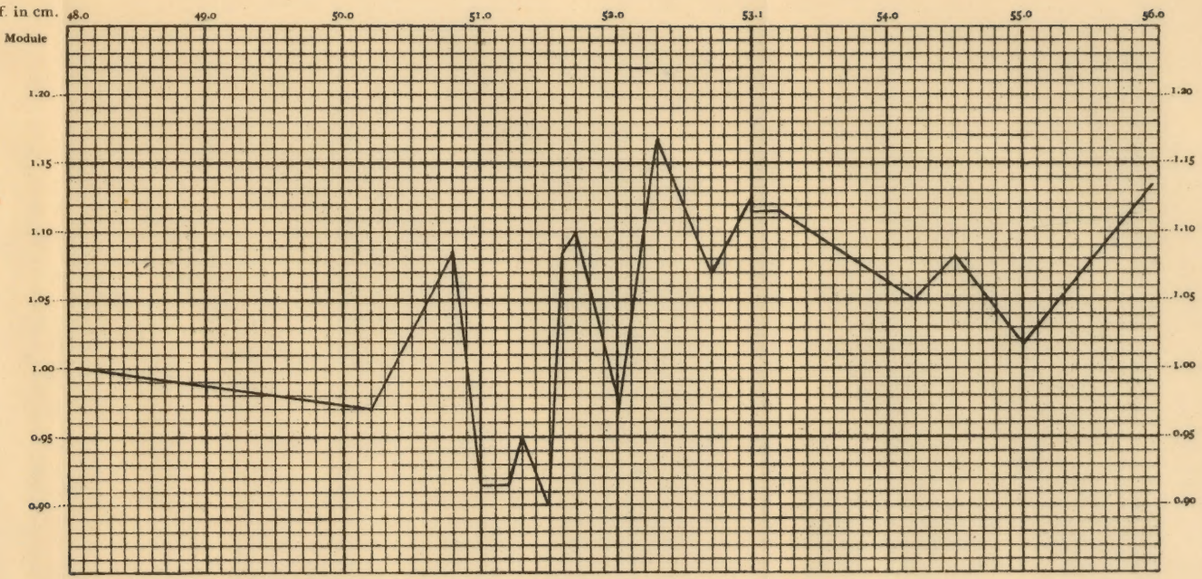
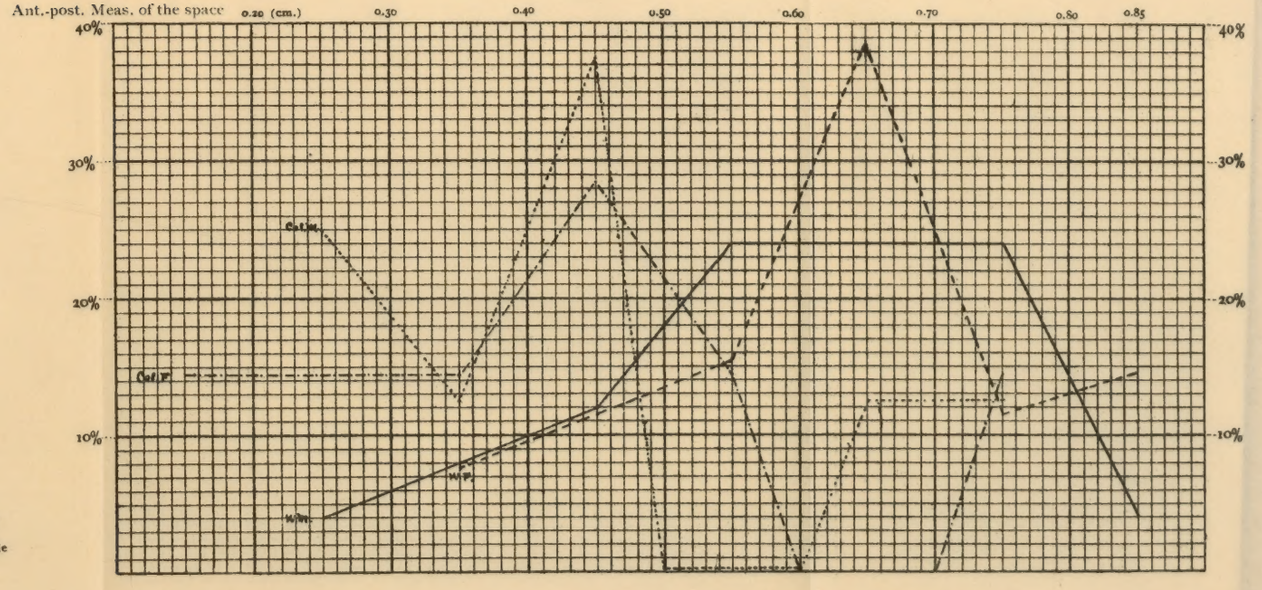


FIG. 2.—CURVES SHOWING THE DIFFERENCES IN THE ANTERO-POSTERIOR EXTENT OF THE SPACE INCLOSED WITHIN THE TWO OLIVARY RIDGES, IN FRONT OF THE PITUITARY FOSSA, BETWEEN THE WHITES AND THE NEGROES OF BOTH SEXES.



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